Week 4
JPL Snow Server

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ARSET

Applied **R**emote **SE**nsing **T**raining

A project of NASA Applied Sciences

Outline:
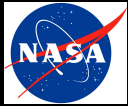# Introduction to the Snow Data System

1   Data Sets and Functionality

2   Near Real Time and Historical MODIS Snow Cover and Size processing systems

3   Near Real Time and Historical MODIS Dust Radiative Forcing processing systems

4   Data Access:

      Western Energy Balance of Snow (WEBS)

      SNOWMAP (map overlays)
      Web-based Distributed Authoring and Versioning (WebDAV)

Objectives

- Understand how we get from raw MODIS surface reflectance products, and LANCE MODIS near real-time (NRT) products to Snow Covered Area and Grain Size, and Dust radiative forcing products
- Understand how to get data from JPL Snow Server
- Understand how to use JPL WEBS and SNOWMAP

# Satellites providing Snow Products

Satellite	Sensors	Quantities
Terra	MODerate Resolution Imaging Spectroradiometer (MODIS) 500 m spatial resolution ~daily temporal resolution	• Snow covered area • Snow albedo • Snow grain size • **Dust/BC radiative forcing**
Aqua	MODerate Resolution Imaging Spectroradiometer (MODIS) 500 m spatial resolution ~daily temporal resolution	• Snow covered area • Snow albedo • Snow grain size • **Dust/BC radiative forcing**
NPOESS Preparatory Project (NPP) - Suomi	Visible Infrared Imaging Radiometer Suite (VIIRS) 750m spatial resolution ~daily temporal resolution	• Snow covered area • Snow albedo • Snow grain size • **Dust/BC radiative forcing**
Landsat Data Continuity Mission (LDCM) (launch February 2013)	Operational Land Imager (OLI) 30 m spatial resolution 16-day temporal resolution	• Snow covered area • Snow albedo • Snow grain size • **Dust/BC radiative forcing**

JPL Snow Server

- http://snow.jpl.nasa.gov
- Full bore processing and delivery system
  - Near real time and historical processing
  - Dust forcing and snow covered area products
  - Tower data
  - GIS interfaces
 - CSV, JSON, GeoTIFF data format download
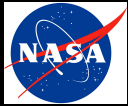
Apache OODT

- Entered "incubation" at the Apache Software Foundation in 2010
- Selected as a top level Apache Software Foundation project in January 2011
- Developed by a community of participants from many companies, universities, and organizations
- Used for a diverse set of science data system activities in planetary science, earth science, radio astronomy, biomedicine, astrophysics, and more

http://oodt.apache.org

OODT Development & user community includes:
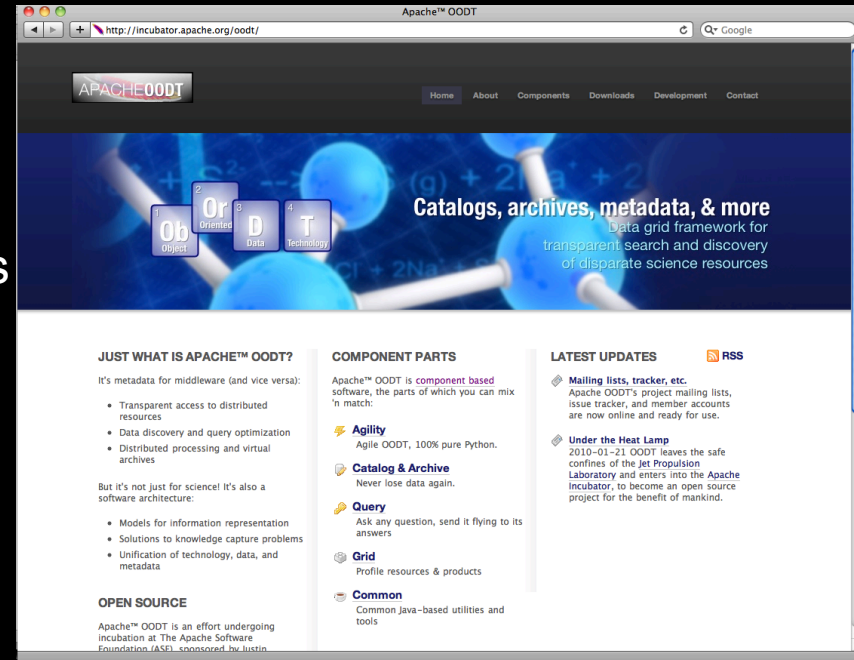
Apache OODT Core Components
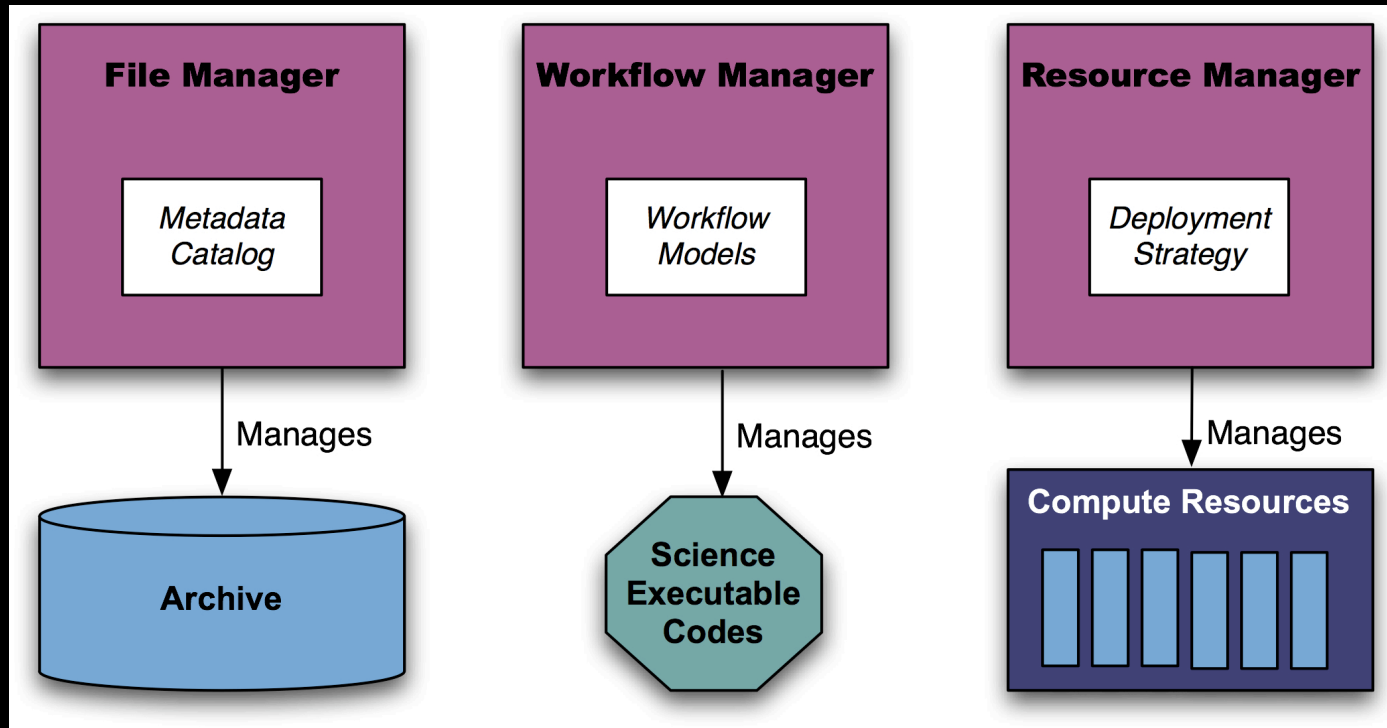
- **All Core components implemented as web services**
  - XML-RPC used to communicate between components
  - Servers implemented in Java
  - Clients implemented in Java, scripts, Python, PHP and web-apps
  - Service configuration implemented in ASCII and XML files

MODIS Snow Covered Area and Grain Size (MODSCAG)

JPL MODSCAG algorithm
(Painter et al 2009)
Spectral mixture analysis of
MODIS Surface
Reflectance products

Daily 500 m coverage in
late morning and early
afternoon from NASA
satellites Terra and Aqua
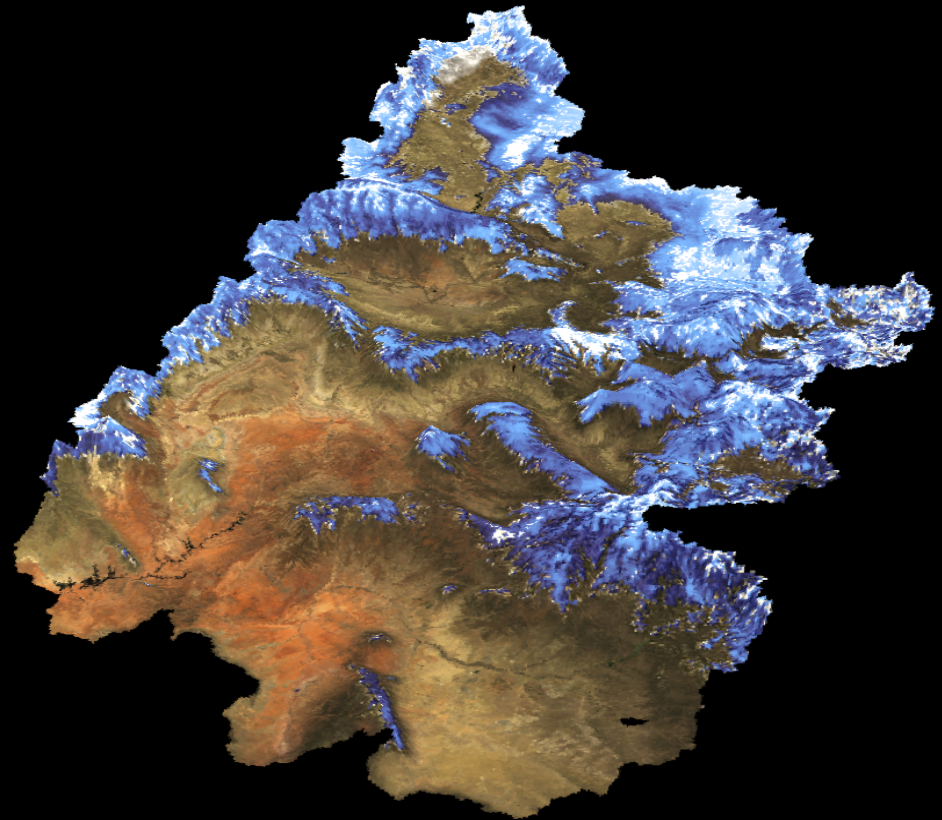
Color Composite	MODSCAG	MOD10A1	Thematic Mapper

7 July, 2006

1.0
0.8
0.6
0.4
0.2
0.0
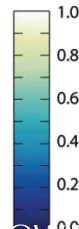
Upper Colorado River Basin

March 9, 2009

8

MODSCAG Processing: Two Products/ Two Inputs

- MODIS tiles are defined by their horizontal and vertical tile IDs (the 2 characters after the h and the v respectively)

- Historical Tiles over the Western United States (LPDAAC)
  - Time Range: 2000 - Present
  - h08v04, h08v05, h09v05, h09v04, h10v04
  - LPDAAC is NASA Land Processes data center located at the USGS Earth Resources Observation and Science (EROS) Center in Sioux Falls, South Dako

- MODIS Near Real-Time Products (LANCE MODIS NRT)
  - Time Range: Dec 2011 - Present
  - Western United States
  - High Asia

MODSCAG Historical Data Processing (144 Cores)

1. Crawler collects files and passes them to the File Manager for Ingestion

2. File Manager will extract metadata and archive the MOD09GA Products

3. Workflow submit's MODSCAG jobs to the Resource Manager

4. Resource Manager schedules and submits jobs to the cluster nodes via BatchStubs that run on each machine

5. When processing is completed, the outputs are re-ingested via the File Manager on snow.jpl.nasa.gov

MODSCAG Near Real-Time Process Flow (48 Cores)

Data from LANCE

(NRT MOD09GA Tiles)

SNOW SERVER

FileManager

Metadata Catalog

Product Archive

KUSH SERVER

1 Crawler

2 Workflow

Resource Manager

3

BatchStubs (8)

48 Core Compute Cluster

4

1. Crawler Ingests the LANCE Data into the Catalog Archive on the Snow Server

2. Workflow submits MODSCAG jobs to the Resource Manager.

3. The Resource Manager schedules jobs across the 48 Cores and monitor's their progress via BatchStubs.

4. When a MODSCAG job is complete, the end products are Cataloged and Archived by the Snow Server

OODT Components   Data Storage

Dust Radiative Forcing
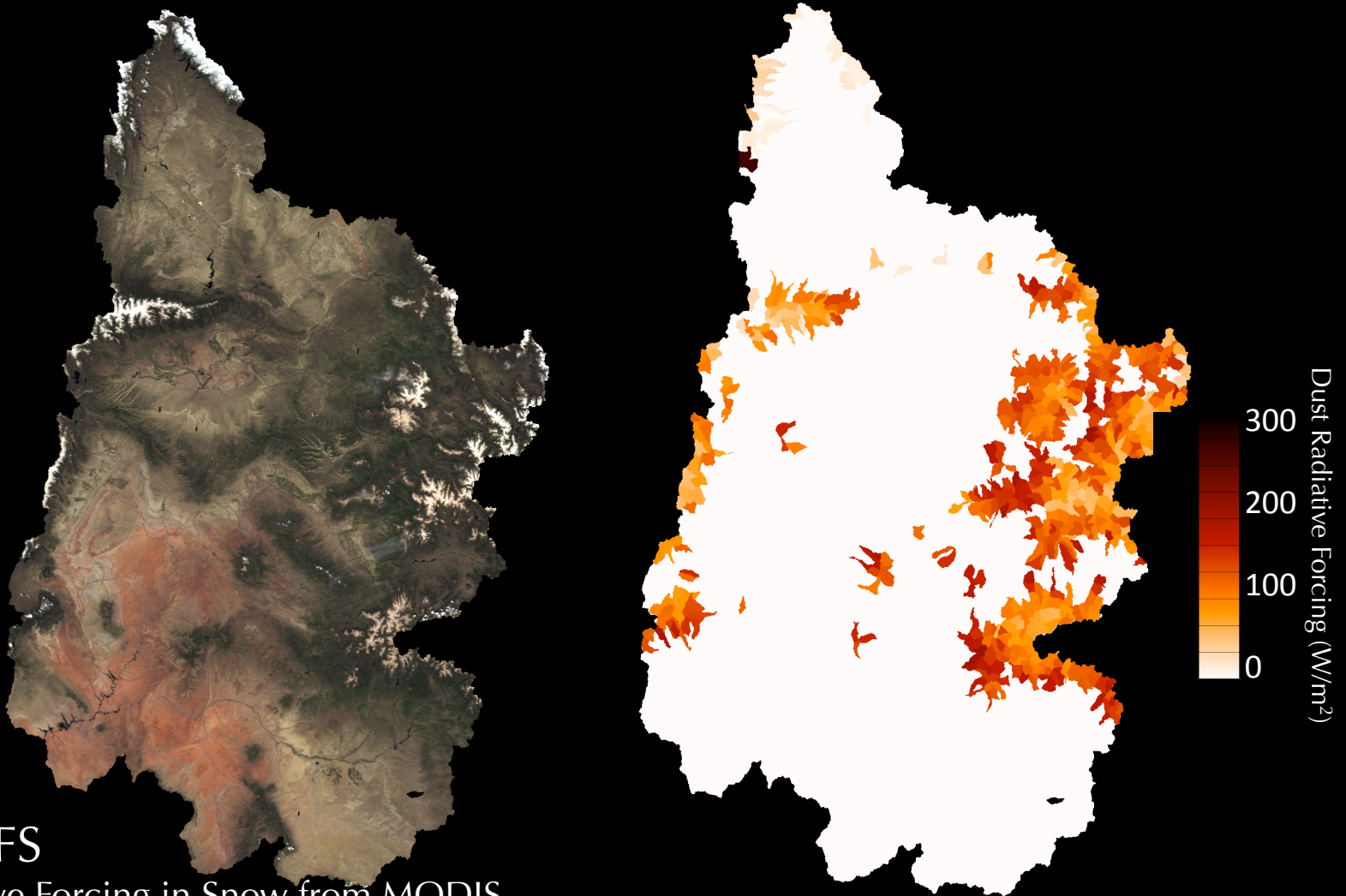
MODDRFS
Dust Radiative Forcing in Snow from MODIS
Painter and Bryant, 2012

Feb 2 2015

ARSET-SNOW-W4

17 May 2009

Dust Radiative Forcing Processing

Obtain MOD09GA Surface Reflectance Tiles for the Upper Colorado River Basin (h08v05, h09v04, h09v05, h10v05).

↓

MODSCAG/MOD-DRFS file preparation: HDF extraction of surface reflectance bands, cloud properties, solar and sensor geometry.

↓

MOD-DRFS algorithm computes radiative forcing by dust on snow.

↓

MODSCAG/MOD-DRFS post-processing: cloud masking and de-striping

Dr. Tom Painter's Western Energy Balance of Snow (WEBS) Tower Network
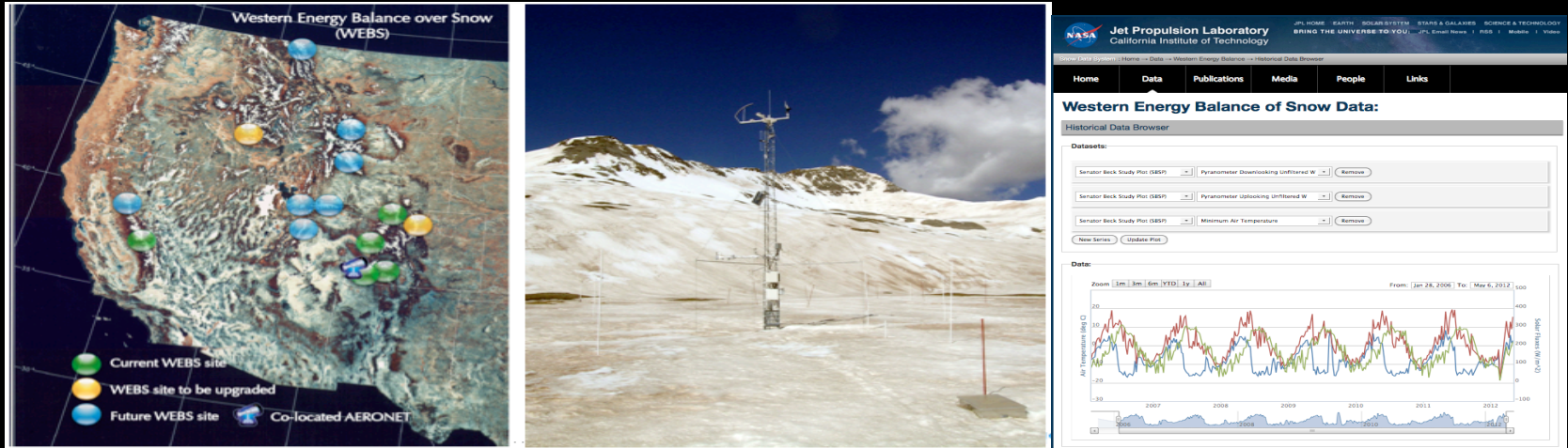
- Network of heavily instrumented towers in snow- covered regions to facilitate modeling of the energy balance and melt of the snow cover, and dust/BC radiative forcing in the snow cover.
- Standard measurements of meteorology (air temperature, wind speed, relative humidity, all at two heights), also incident and reflected broadband solar radiation and incident and reflected near infrared/shortwave infrared   solar radiation

Western Energy Balance of Snow

- Western Energy Balance of Snow (WEBS)

  – Historical And Near-Real-Time Access

- Towers deployed in several key snow areas

- Connect to towers and pull down data actively
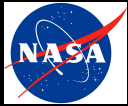
WEBS Data Processing

http://snow.jpl.nasa.gov/portal/data/webs

- Historical data:

  – Swamp Angel Study Plot: WY 2006 – Present

  – Senator Beck Study Plot: WY 2006 – Present

  – Grand Mesa Study Plot: WY 2009 – Present

- Near-real-time collection:

  – Automated hourly refresh rate

- Data Access

  – Interactive browser-based visualization

  – Customizable data product download
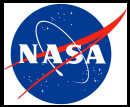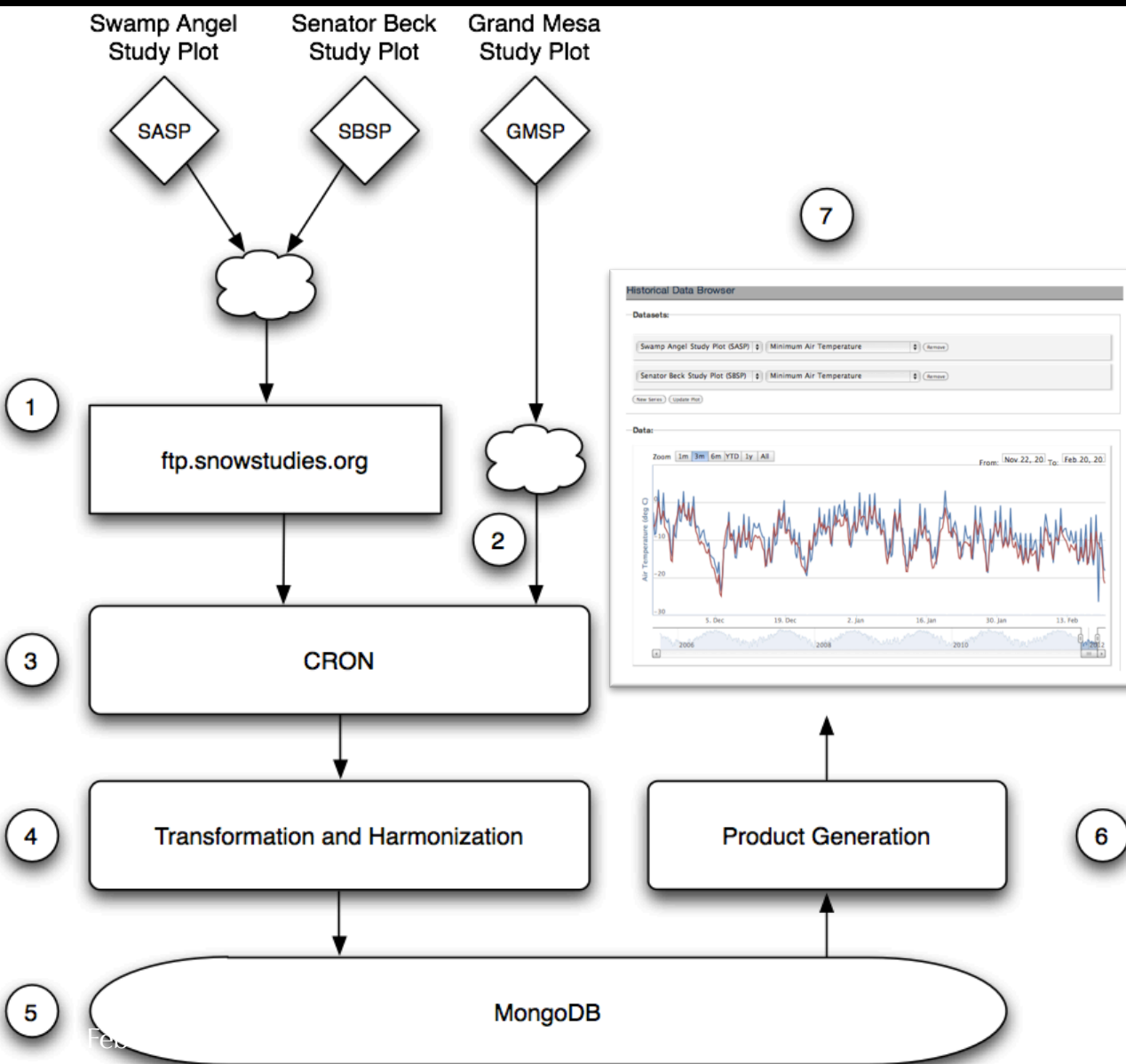
1) Data from SASP and SBSP staged to ftp.snowstudies.org

2) Data from GMSP obtained by direct connection to the tower

3) A Cron job pulls down the latest hourly data

4) Data from all stations is homogenized and cleaned

5) Data is stored in MongoDB for fast, scalable querying

6) Data is selectively extracted and formatted as needed for data delivery

7) Users interact with, and request, data via a browser-based interface.

WEBS Browser Interface

http://snow.jpl.nasa.gov/portal/data/webs

- Access to tower-specific information

- Access to the full range of historical data

WEBS Browser Interface

- Detailed Tower Information
  - Geographical location
  - Equipment background
  - Latest observational data
  - Site Photos
- Data Download via CSV
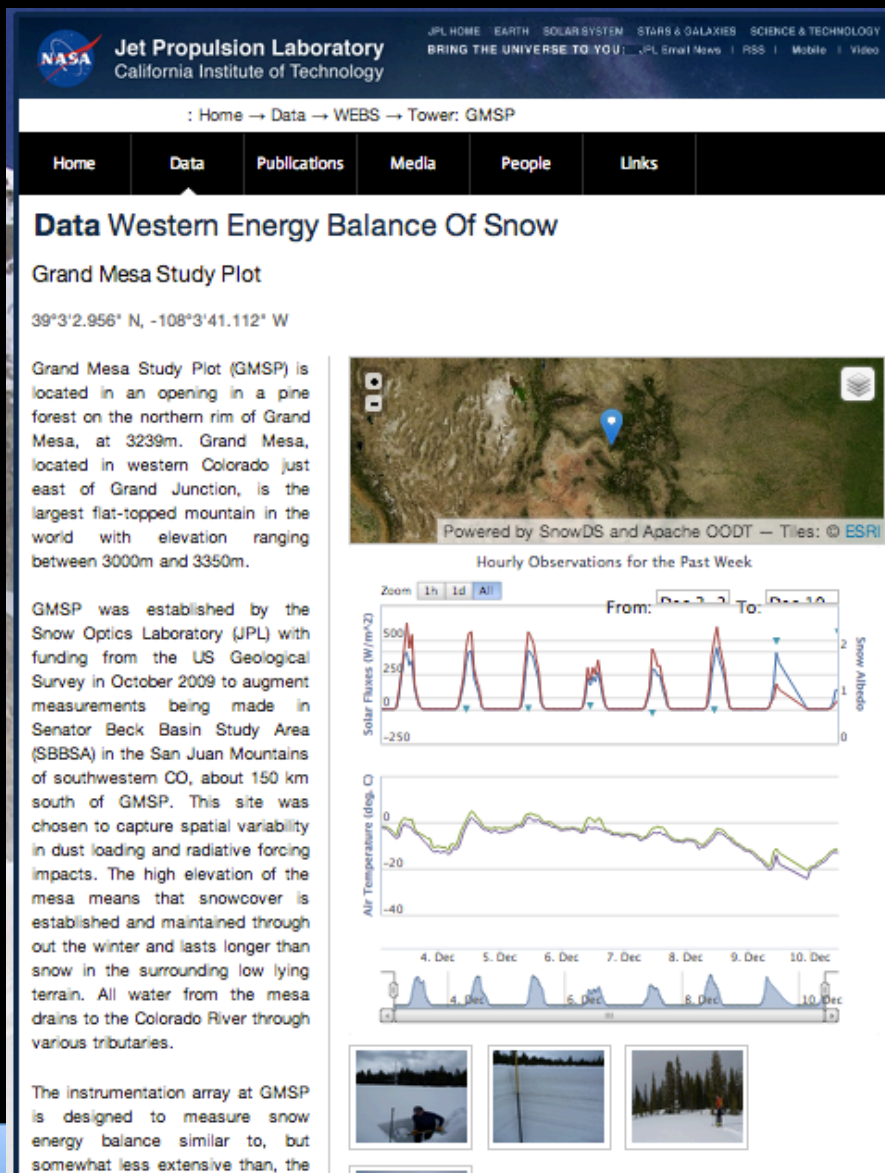
WEBS Browser Interface
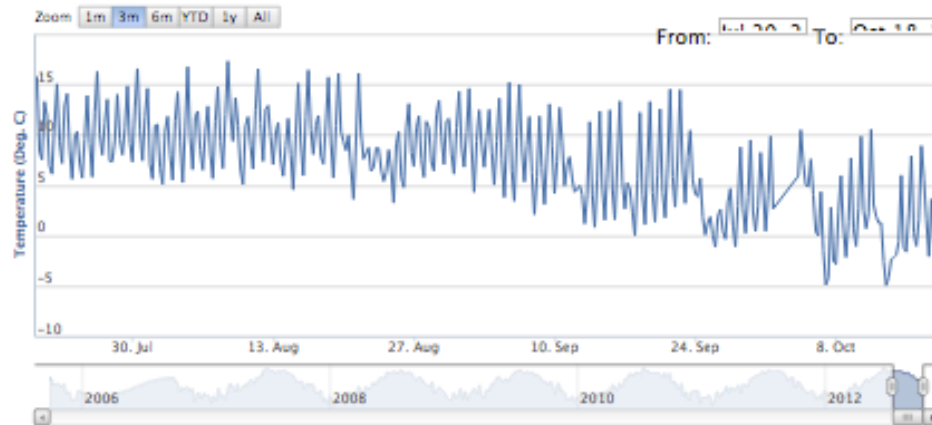
Interactive data visualization

- Select towers

- Select parameters

- Select date ranges

- Select download format as CSV, JSON, etc.

SNOWMAP– http://snow.jpl.nasa.gov/portal/data/map

- Showing snow covered area layer and clouds

- Products available as WMS (variety of formats)
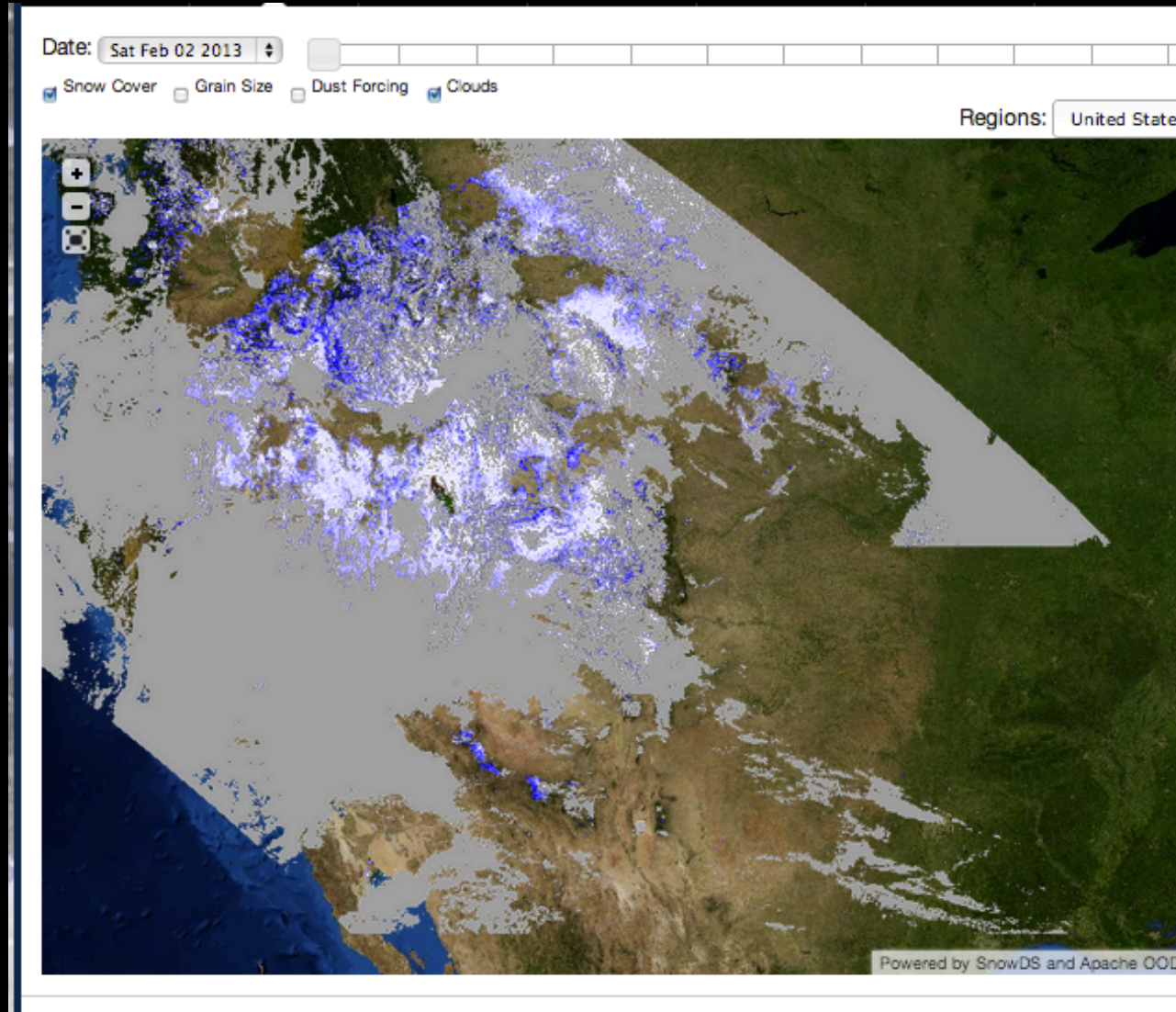
Access to Snow Products via GIS

- Use GIS tools (shown in next slides after terminology) to
  - Download Snow datasets as GeoTIFF, Raster
  - Reproject the data into your own coordinate reference systems
  - Browse/interact with the data
  - Store the data in databases like PostGIS and compute distances, geometric functions, etc.

GIS Terminology

- **OGC** - The *Open Geospatial Consortium* is an international consortium of companies, government agencies, and universities participating in a consensus process to develop publicly available geospatial and location-based services. Interfaces and protocols defined by OpenGIS specifications support interoperability and seek to integrate geospatial technologies with wireless and location-based services

- **Raster** - A spatial data model that defines space as an array of equally sized cells arranged in rows and columns, and composed of single or multiple bands. Each cell contains an attribute value and location coordinates. Unlike a vector structure, which stores coordinates explicitly, raster coordinates are contained in the ordering of the matrix. Groups of cells that share the same value represent the same type of geographic feature.

- **Vector** - A coordinate-based data model that represents geographic features as points, lines, and polygons. Each point feature is represented as a single coordinate pair, while line and polygon features are represented as ordered lists of vertices. Attributes are associated with each vector feature, as opposed to a raster data model, which associates attributes with grid cells.

- **KML** - Keyhole Markup Language (KML) is an XML notation for expressing geographic annotation and visualization within Internet-based, two-dimensional maps and three-dimensional Earth browsers. Originally developed by Google for Google Earth and later turned over to the OGC for standardization.

Credit Paul Ramirez 2011-2012

GIS Terminology Con't

- *Map* - A graphic representation of the spatial relationships of entities within an area.
- *WMS* - is a standard protocol for serving georeferenced map images over the Internet that are generated by a map server using data from a GIS database. The specification was developed and first published by the OGC in 1999
- *Feature* - A representation of a real-world object on a map.
- *WFS* - The OGC Web Feature Service Interface Standard (WFS) provides an interface allowing requests for geographical features across the web using platform-independent calls. One can think of geographical features as the "source code" behind a map.
- *Coverage* – Mapping of one aspect of data in space. It represents a "domain" in terms of of characteristics expressing a range of values. For example: a satellite image derived from remote sensing might record varying degrees of light pollution. Aerial photography, land cover data, and digital elevation models all provide coverage data.
- *WCS* – The OGC Web Coverage Service (WCS) provides and interface allowing requests for geographical coverages across the web using platform-independent calls.

Credit Paul Ramirez 2011-2012
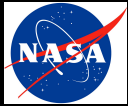
GIS Architecture Stack
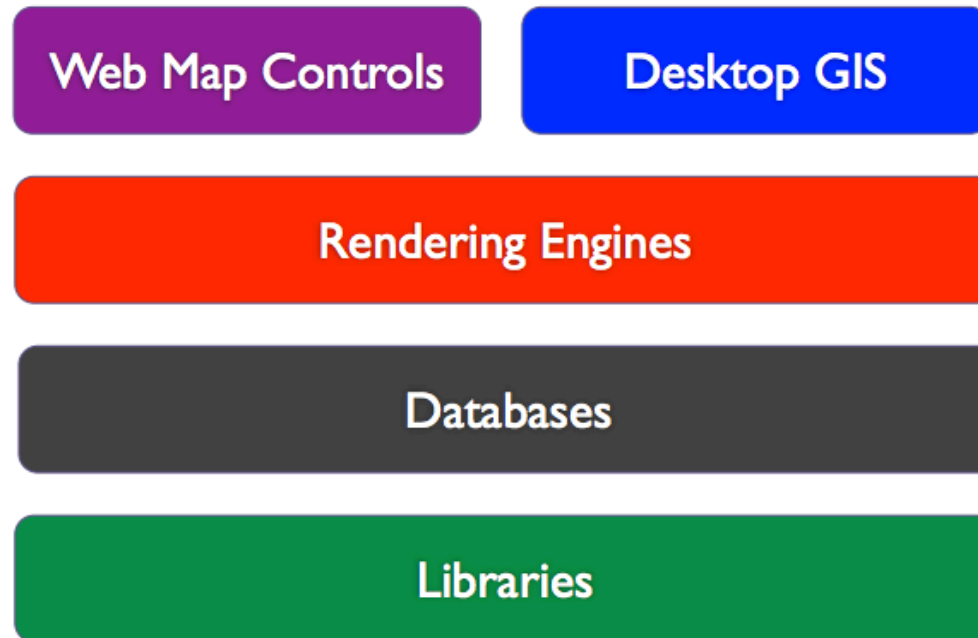
Credit Paul
Ramirez
2011-2012

Source: http://foss4g-na.org/wp-content/uploads/2012/03/RamseyKeynote.pdf
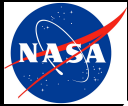
GIS tools for JPL Snow Server Data
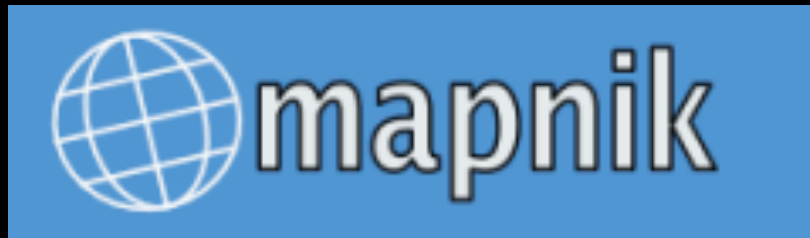
Credit Paul Ramirez 2011-2012

Web Map Controls
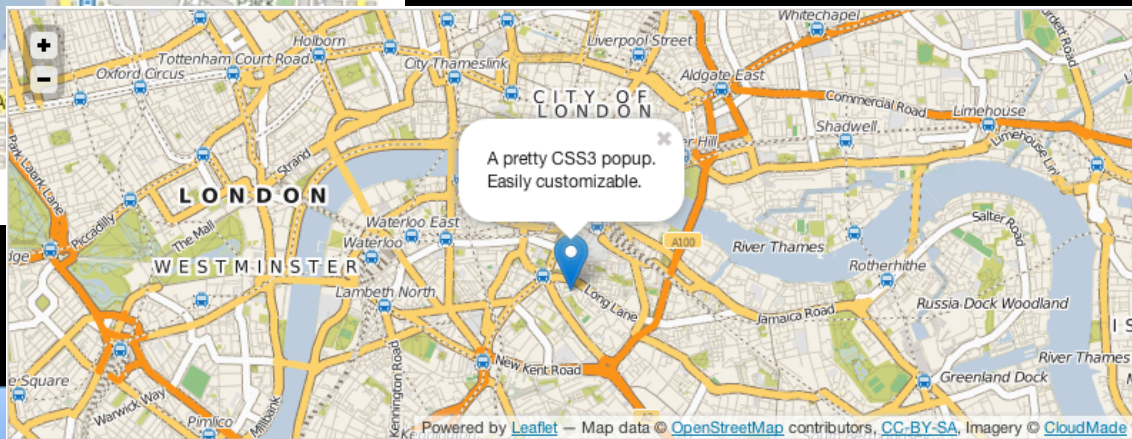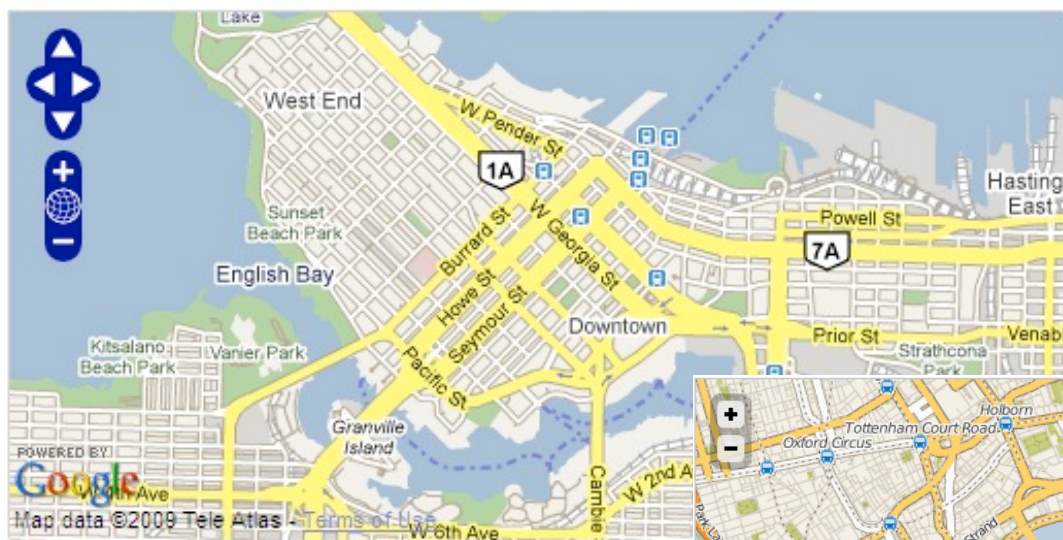
Credit Paul Ramirez 2011-2012

Desktop
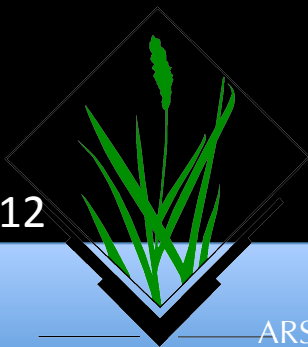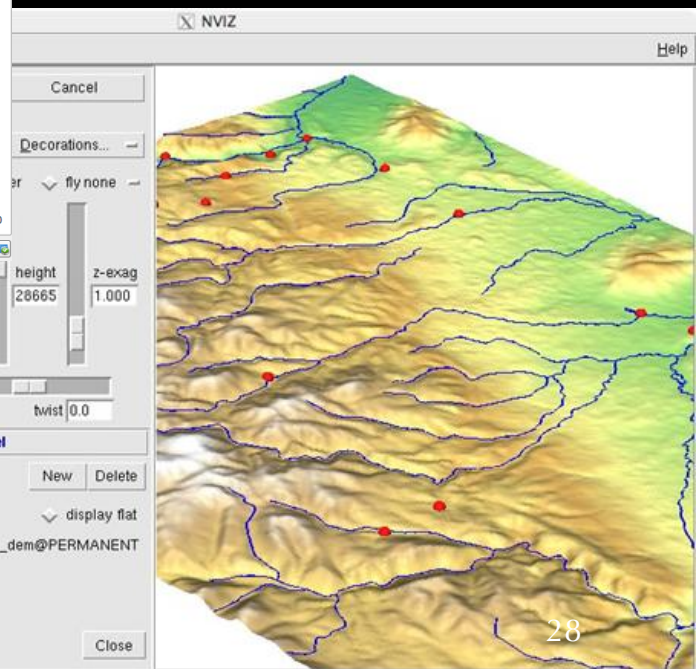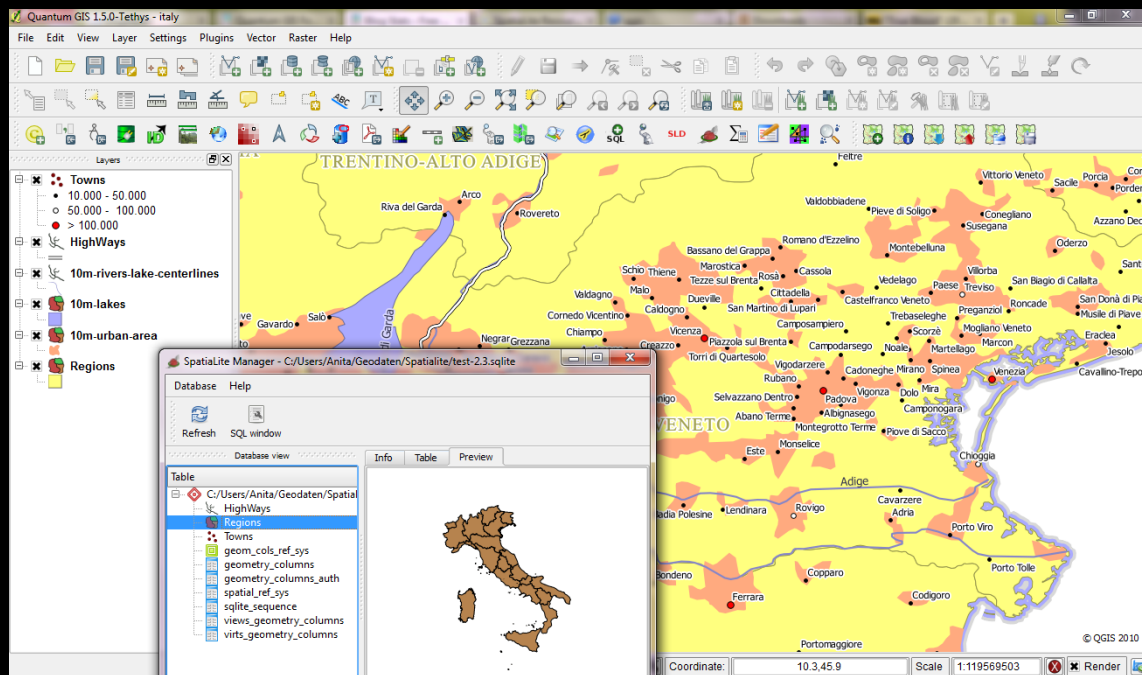
Credit Paul Ramirez 2011-2012

Snow Map Architecture

Layers available
    Snow Cover
    Grain Size
    Clouds
    Dust Forcing

Snow Map

Snow Data System

GIS Server

ESRI Basemaps

http://snow.jpl.nasa.gov/gis/wms

GeoTIFFs on Disk

PostGIS

Credit Paul Ramirez 2011-2012
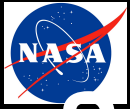
Snow Map Detail
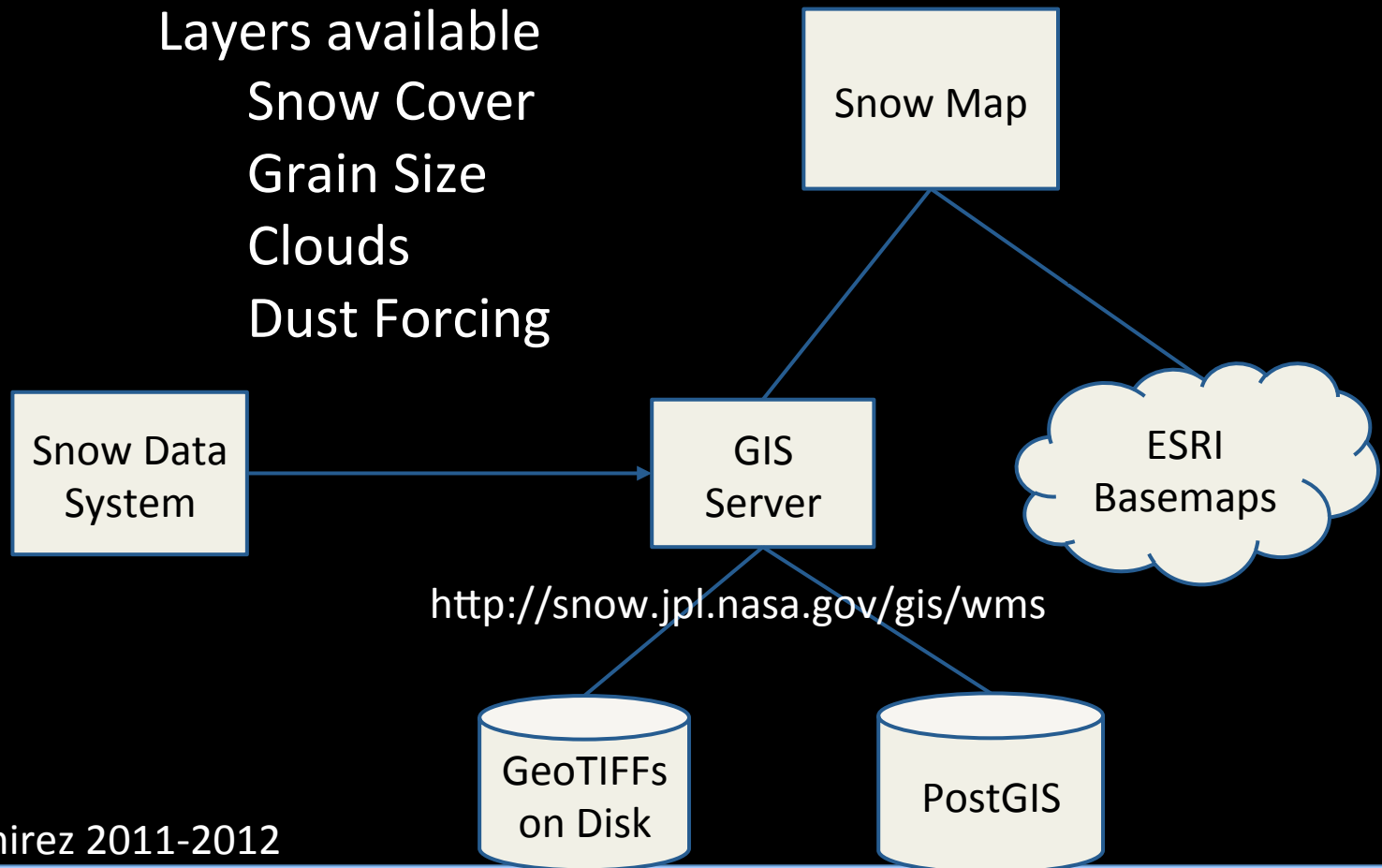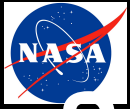
Use WMS - http://snow.jpl.nasa.gov/gis/wms

- Many GIS components support this out of the box.
- For instance, Leaflet that we use for our map

Layers exposed via WMS will be timed based

- Historical dataset
- Lance NRT

Define styles for the data using Styled Layer Descriptor

- SLD is a standard and supported by most GIS servers
- Easily change styles or support multiple styles per layer
- Clients can pick from available styles on a layer

Expose tower based information using WFS

- Click on a tower to get a graph

Publish our own basemap if needed

- For instance a hillshade or color hillshade on the DEM used during processing

Data Browse and Download

Click on data tab

Click Snow data product browser

Data Product Browse/Download

- Select dust forcing (MOD-DRFS) or Snow Covered Area (MODSCAG)

Product File Browser

- Select a product
- View received time
- Sorted by received time
  - Latest on top

Per Product Metadata

- View product metadata including upstream pedigree, and processing information

WebDAV Data Delivery

- Web-based Distributed Authoring and Versioning (WebDAV)
- Clients available on every major operating system
  – Can mount as disk on Mac
  – Can mount as folder on Win
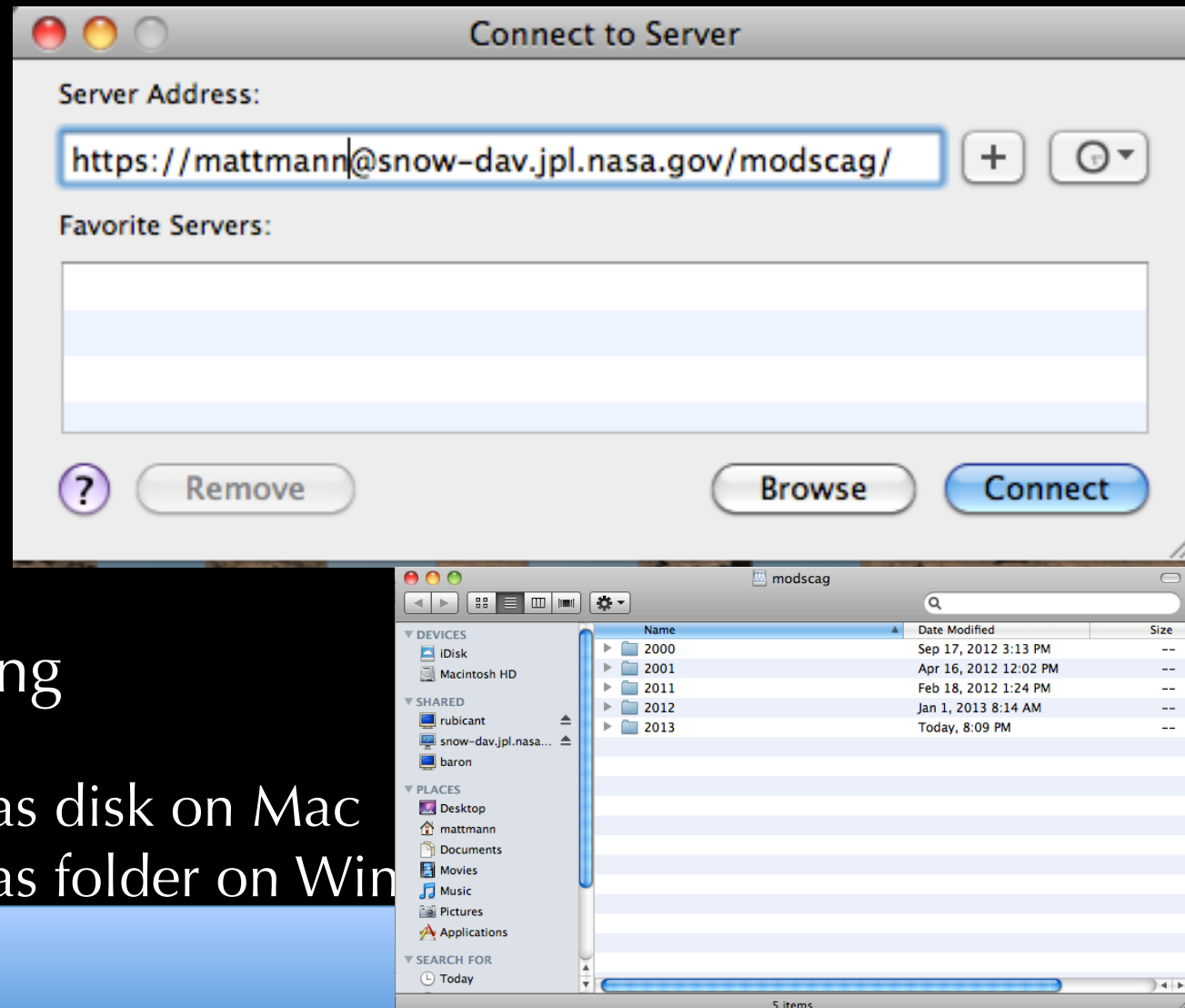
# Data available on WebDAV

- Snow Covered Area
  - Historic pipeline and NRT
- Dust Radiative Forcing
  - Historic pipeline and NRT
- URLs and user accounts are provided to users after agreement with Dr. Painter

Collaborations and Users

- Funded work on NASA Water Resources, and on Airborne Snow Observatory demonstration
  - NOAA Colorado Basin River Forecast Center
  - California Department of Water Resources
  - Bureau of Reclamation
- Discussions ongoing with ESRI and Google Earth Engine
- Partnering with UCLA on WEBS
  - McKenzie Skiles
- NSIDC, Mary Jo Brodzkik & Marilyn Kamanski
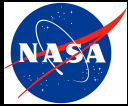
Summary

- Snow Covered Area and Dust radiative forcing pipelines for NRT and historic processing
- Western Energy Balance of Snow data
- SNOWMAP GIS
- Data products available via multiple mediums
  - HTTP/Portal, WebDAV
- And multiple formats (CSV, JSON, GeoTIFF)

You're done!

- We hope you have had a great experience!
- *Feedback about course content – expect a survey from us* it will be short and will help us make the course useful to YOU

- Thank you!